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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Attorney Docket No. MA-046

In re patent application of

Michael A. Vyvoda et al.

Serial No. 09/918,853 — Group Art Unit: 2823

Filed: July 30, 2001 — Examiner: Fernando L. Toledo

For: PROCESS FOR FABRICATING A DIELECTRIC FILM USING PLASMA OXIDATION

REPLY BRIEF

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

April 12, 2006

To the Commissioner:

The above-captioned case is under appeal. Appellant respectfully files this Reply Brief in response to the Examiner's Answer mailed on February 13, 2006. An Appendix listing the pending claims is included in this Reply Brief, as are Exhibits A-D.

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail with sufficient postage to the United States Patent and Trademark Office on the date below.

Pamela J. Squyres, reg. no. 52,246

4/13/06
Date of Deposit

SUMMARY

The following discussion responds to the Examiner's Answer. Rebuttal is made to points raised by the Examiner in his Response to Argument, beginning at paragraph 10 on page 35. In the interest of brevity, Appellant has tried to limit rebuttal to new points raised in the Examiner's Answer. Where Appellant believes the Examiner's arguments to have been sufficiently addressed by the Appeal Brief, those arguments will be allowed to stand and will not be repeated.

DISCUSSION

This Discussion will identify points in the Response to Argument section of the Examiner's Answer that require rebuttal, then will provide such rebuttal.

- **Page 36, paragraph beginning "In the above mentioned passage ..."**

The Examiner argues that the silicon substrate of Thomas is exposed to an oxidizing plasma, finding evidence in Thomas at column 3, lines 8, 33, and 35, and in Figs. 2, 3, and 4. This evidence apparently consists of the appearance of "O^-" in the text and figures. The Examiner presumably takes "O^-" to indicate negatively charged oxygen ions, which he interprets as a plasma.

The Examiner is correct that a plasma is an ionized gas. When sufficient energy is provided to strip electrons from atoms, a plasma is formed, which consists of ions and free electrons, as described in references from a variety of sources included as Exhibits. For example, Exhibit A (from the website of the Los Alamos National Laboratory) describes the four phases of matter: solid, liquid, gas, and plasma. This exhibit, one of many comparable basic physics references, explains on page 2: "Energy is needed to strip electrons from atoms to make plasma. The energy can be of various origins: thermal, electrical, or light ..." The equation in the accompanying chart, in the right-hand column, headed "Plasma", shows a hydrogen molecule, H_2, converted to hydrogen plasma:

$$H_2 \text{->} H^+ + H^+ + 2e^-$$

Note that the hydrogen plasma consists of *positive* hydrogen ions (H^+) and electrons (e^-).

Similarly, Exhibit B, US Patent No. 6,863,784, at col. 6, lines 12-21, describes:

> By way of example, in order to create a plasma, a process gas is input into chamber through the gas port 116. Power is then supplied to the electrodes 104 and 106 and a large electric field is produced between the upper and lower electrodes 104 and 106. As is well known in the art, *the neutral gas molecules of the process gas when subjected to these strong electric fields lose electrons, and leave behind positively charged ions. As a result, positively charged ions, negatively charged electrons and neutral gas molecules are contained inside the plasma.* [Emphasis added.]

In another example, Exhibit C, US Patent No. 6,309,979, describes reactive ion etching, in which plasma 100 includes "positive ions 102 and electrons 104" (col. 1, lines 40-42, referring to Fig. 1.)

In industrial uses, the energy to strip electrons is provided by creation of a large electric field (as described in Exhibit B, US Patent No. 6,863,784, in the passage cited above.)

Plasmas can be formed thermally rather than by a very large electric field (as in plasma reactors), but only at extremely high temperatures. Returning to Exhibit A, the chart on page 2 shows typical temperatures for each phase of matter: Water is solid at less than 0 degrees C, liquid between 0 and 100 degrees C, and gas at more than 100 degrees C. Hydrogen plasma formed by thermal means (with no electric field), however, exists at dramatically higher temperatures, more than 100,000 degrees C.

Exhibit D, from the website of the Solar and Heliospheric Observatory (SOHO, a joint project of NASA and the European Space Agency), the second paragraph, describes an environment in which stripping of electrons to create plasma is achieved by thermal means:

> The gas in the Sun's outer atmosphere is so hot that collisions among the atoms strip off most of the electrons -- creating a gas of positively charged ions and negatively charged electrons, known as a plasma.

Temperatures sufficient to form plasma thermally are found, in short, in environments like the surface of the sun.

Appellant, then, cannot agree with the Examiner's suggestion that flowing oxygen over ceramic heated to 1000 degrees C will form a plasma, as evidenced by the appearance of "O^-" in diagrams and equations of Thomas. Appellant cannot be certain what "O^-" is intended to signify (the equation at col. 3, line 8, for example, is not electrically balanced), but, as will be described, it cannot be oxygen plasma. (Appellant suspects that the equation at col. 3, line 8, of Thomas was at some point incorrectly transcribed. It is likely that the inventor intended the equation at col. 3, line 8, to read thus:

$$O2 \text{->} O\cdot + O\cdot$$

The symbol O· indicates an oxygen radical, which is electrically neutral. This equation is electrically balanced, and O· can accurately be described as "atomic oxygen". It is likely the radical sign ("·") was mistranscribed as a minus ("–") during preparation of this patent application. Thomas nowhere describes disassociated atomic oxygen or nitrogen as negative ions, or as ions of any sort. Appellant freely concedes that this is pure speculation, but it is nonetheless a logical explanation which renders these equations correct.)

First, as described in Exhibits A, B, and D, plasma is formed by stripping *electrons*, which have negative charge, from electrically neutral atoms; thus the ions in a plasma will be predominantly *positive* rather than negative (e.g. O^+, not O^-). Second, 1000 degrees C does not begin to approach the temperature required to produce plasma thermally. As described in Exhibit D, much higher temperatures, like those found at the surface of the sun, in the range of tens of thousands of degrees C, are required to form plasma thermally. Temperatures in the range of 1000 degrees C can be achieved in conventional furnaces; if such a temperature were sufficient to form a plasma, there would be no need for plasma reactors, using RF power at hundreds of watts to create large electrical fields, to exist.

Finally, Appellant will reiterate that Thomas nowhere describes the flow of atomic oxygen reaching the silicon surface as a plasma, and repeatedly describes his oxidation process as *thermal* oxidation, rather than plasma oxidation (title, Abstract, claims ("a method of thermally oxidizing silicon"), etc.) In one embodiment, atomic oxygen may be generated in a remote plasma chamber. It is possible that an oxygen plasma exists *in this remote chamber*. But energy must continually be applied to maintain a plasma; thus even if an oxygen plasma were generated remotely, by the time the oxygen reaches the oxidation vessel,

the electrons would have recombined with the free atoms and could no longer be a plasma, though, as described in Thomas, the oxygen may still exist as oxygen radicals (O·) and may not yet have combined to form oxygen molecules (O_2).

- **Paragraph beginning "Appellant further argues ..."**

Examiner points to col. 3, lines 13-14 of Thomas s evidence of controlling plasma activity:

> The heating elements 24 are controlled to provide a temperature ramp rate of 100° C per minute or greater.

Clearly the temperature of the chamber can be varied; unless a different chamber is to be used for each temperature, this is to be assumed. Thomas describes raising substrate temperature to 500 degrees C (col. 2, lines 39-43). At no point, however, does Thomas describe varying temperature during oxidation *to control the rate of oxidation*, as recited in claim 113 and related claims.

Appellant believes the remainder of the Examiner's arguments have largely been addressed either in the Appeal Brief or in this Reply Brief and thus will not repeat them here.

CONCLUSION

Appellant respectfully solicits the Honorable Board of Patent Appeals and Interferences to reverse the rejections of the pending claims and pass this application on to allowance.

4/12/06
Date

Respectfully submitted,

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APPENDIX

1. A plasma oxidation process comprising:

exposing an oxidizable surface to an oxidizing plasma,

wherein the oxidizing plasma has an activity relative to the oxidizable surface;

forming an oxide film on the oxidizable surface; and

regulating the oxidizing plasma activity to limit a rate of formation of the oxide film.

2. The plasma oxidation process of claim 1, wherein regulating the oxidizing plasma activity comprises bombarding the oxidizable surface with energized ions prior to exposing the oxidizable surface to the oxidizing plasma.

3. The plasma oxidation process of claim 2, wherein bombarding the oxidizable surface comprises bombarding the oxidizable surface to remove contaminants from the oxidizable surface.

4. The plasma oxidation process of claim 2, wherein bombarding the oxidizable surface comprises bombarding the oxidizable surface to remove other oxide layers present on the oxidizable surface.

5. The plasma oxidation process of claim 2, wherein bombarding the oxidizable surface comprises bombarding the oxidizable surface to facet the oxidizable surface.

6. The plasma oxidation process of claim 2, wherein bombarding the oxidizable surface with energized ions comprises subjecting the oxidizable surface to a bias voltage.

7. The plasma oxidation process of claim 1, wherein regulating the oxidizing plasma activity comprises diluting the oxidizing plasma with an inert gas.

8. The plasma oxidation process of claim 1 further comprising providing a substrate having a back surface opposite a face surface, wherein the oxidizable surface comprises at least a portion of the face surface, and wherein regulating the oxidizing plasma activity comprises contacting the back surface with a cooling medium.

9. The plasma oxidation process of claim 1, wherein regulating the oxidizing plasma activity comprises applying an RF bias voltage to the oxidizable surface.

10. The plasma oxidation process of claim 1 further comprising:

providing a plasma chamber;

placing a substrate in the plasma chamber; and

igniting the oxidizing plasma after placing the substrate in the plasma chamber.

11. The plasma oxidation process of claim 1 further comprising igniting an inert gas plasma prior to igniting the oxidizing plasma.

12. The plasma oxidation process of claim 11 further comprising placing the oxidizable surface in the inert gas plasma.

13. The plasma oxidation process of claim 1 further comprising providing a plasma power source having an output power, and wherein regulating the oxidizing plasma comprises limiting the output power to a predetermined level.

14. The plasma oxidation process of claim 1, wherein the oxidizable surface comprises silicon.

15. The plasma oxidation process of claim 1, wherein the oxidizable surface comprises a semiconductor element of an antifuse device.

16. The plasma oxidation process of claim 1, wherein exposing an oxidizable surface to an oxidizing plasma comprises exposing the oxidizable surface to a plasma comprising oxygen.

17. The plasma oxidation process of claim 1, wherein regulating the oxidizing plasma activity comprises applying a bias voltage and sputtering a portion of the oxide film while simultaneously forming the oxide film.

18. A process for fabricating an oxide film in a semiconductor device comprising the steps of:

forming a semiconductor layer;

exposing the semiconductor layer to a plasma comprising oxygen,

wherein the plasma has an activity relative to the semiconductor layer;

forming an oxide film on the semiconductor layer; and

regulating the plasma activity to limit a rate of formation of the oxide film.

19. The process of claim 18, wherein the step of forming a semiconductor layer comprises forming a doped semiconductor layer.

20. The process of claim 18, wherein the step of forming a semiconductor layer comprises forming a silicon layer.

21. The process of claim 18, wherein the step of forming a semiconductor layer comprises forming a germanium layer.

22. The process of claim 18 further comprising forming an electrically conductive layer prior to forming the semiconductor layer.

23. The process of claim 18, wherein the oxide film comprises a gate oxide layer.

24. The process of claim 18, wherein the oxide film comprises a passivation layer.

25-34. (Withdrawn)

35. A process for forming an antifuse comprising:

exposing an oxidizable surface to an plasma oxidation process for an initial exposure time; and

growing an oxide film on the oxidizable surface, and

wherein the oxide film grows to a predetermined thickness at an end of the initial exposure time, and wherein additional exposure to the plasma oxidation process beyond the initial exposure time does not result in a significant further increase in thickness of the oxide film.

36. The process of claim 35, wherein the plasma oxidation process comprises providing a substrate having a back surface opposite a face surface, wherein the oxidizable surface comprises at least a portion of the face surface, and contacting the back surface with a cooling medium.

37. The process of claim 35, wherein the plasma oxidation process comprises applying an RF bias voltage to the oxidizable surface.

38. The process of claim 35, wherein the plasma oxidation process comprises generating a plasma comprising oxygen and an inert gas.

39. The process of claim 35, further comprising subjecting the oxidizable surface to a plasma containing a nitrogen species prior to exposing the oxidizable surface to a plasma oxidation process.

40. The process of claim 39, wherein subjecting the oxidizable surface to a plasma containing a nitrogen species comprises subjecting the oxidizable surface to a plasma formed by a gas selected from the group consisting of nitrogen, nitrous oxide and ammonia.

41-54. (Withdrawn)

55. A process for fabricating a dielectric film in a semiconductor device comprising the steps of:

exposing an oxidizable surface to a plasma comprising an oxygen species and a nitrogen species,

wherein the plasma has an activity relative to the oxidizable surface;

forming an oxynitride film on the oxidizable surface; and

regulating the plasma activity to limit a rate of formation of the oxynitride film.

56. The process of claim 55, wherein the nitrogen species comprises a compound selected from the group consisting of nitrogen, ammonia and nitrous oxide.

57. The process of claim 55, wherein the step of forming an oxynitride film comprises a gate oxide layer.

58. The process of claim 55, wherein the step of forming an oxynitride film comprises a passivation layer.

59. The process of claim 55, wherein the step of forming an oxynitride film comprises an antifuse layer.

60. The process of claim 55, further comprising subjecting the oxidizable surface to a plasma containing a nitrogen species prior to exposing the oxidizable surface to a plasma comprising an oxygen species and a nitrogen species.

61. The process of claim 60, wherein subjecting the oxidizable surface to a plasma containing a nitrogen species comprises subjecting the oxidizable surface to a plasma formed by a gas selected from the group consisting of nitrogen, nitrous oxide and ammonia.

62. A process for fabricating an oxide film in a semiconductor device comprising the steps of:

exposing an oxidizable surface to a plasma comprising oxygen,

wherein the plasma has an activity relative to the oxidizable surface;

forming an oxide film on the oxidizable surface;

regulating the plasma activity to limit a rate of formation of the oxide film; and

forming a silicon nitride layer overlying the oxide film.

63. The process of claim 62, wherein the step of forming a silicon nitride layer comprises plasma deposition of silicon nitride.

64. The process of claim 62, wherein the step of forming a silicon nitride layer comprises chemical vapor deposition of silicon nitride.

65. The process of claim 62, further comprising subjecting the oxidizable surface to a plasma containing a nitrogen species prior to exposing the oxidizable surface to a plasma comprising oxygen.

66. The process of claim 65, wherein subjecting the oxidizable surface to a plasma containing a nitrogen species comprises subjecting the oxidizable surface to a plasma formed by a gas selected from the group consisting of nitrogen, nitrous oxide and ammonia.

67. A process for fabricating a dielectric film in a semiconductor device comprising the steps of:

exposing an oxidizable surface to a plasma comprising an oxygen species, wherein the plasma has an activity relative to the oxidizable surface;

forming an oxide film having an upper surface on the oxidizable surface;

regulating the plasma activity to limit a rate of formation of the oxide film; and forming an oxynitride region at the upper surface of the oxide film.

68. The process of claim 67, wherein the step of forming an oxynitride region comprises subjecting the oxide film to a plasma containing a nitrogen species.

69. The process of claim 68, wherein subjecting the oxide film to a plasma containing a nitrogen species comprises subjecting the oxide film to a plasma formed by a gas selected from the group consisting of nitrogen, nitrous oxide and ammonia.

70. The process of claim 67, further comprising subjecting the oxidizable surface to a plasma containing a nitrogen species prior to exposing the oxidizable surface to a plasma comprising oxygen.

71. The process of claim 70, wherein subjecting the oxidizable surface to a plasma containing a nitrogen species comprises subjecting the oxidizable surface to a plasma formed by a gas selected from the group consisting of nitrogen, nitrous oxide and ammonia.

72. A plasma oxidation process comprising:

exposing an oxidizable surface to an oxidizing plasma,

wherein the oxidizing plasma has an activity relative to the oxidizable surface;

forming an oxide film on the oxidizable surface; and

regulating the oxidizing plasma activity to limit a rate of formation of the oxide film by regulating at least one of the following: reaction kinetics, growth initiation, and surface energy.

73. The plasma oxidation process of claim 72, wherein regulating the oxidizing plasma activity comprises bombarding the oxidizable surface with energized ions prior to exposing the oxidizable surface to the oxidizing plasma.

74. The plasma oxidation process of claim 73, wherein bombarding the oxidizable surface comprises bombarding the oxidizable surface to remove contaminants from the oxidizable surface.

75. The plasma oxidation process of claim 73, wherein bombarding the oxidizable surface comprises bombarding the oxidizable surface to remove other oxide layers present on the oxidizable surface.

76. The plasma oxidation process of claim 73, wherein bombarding the oxidizable surface comprises bombarding the oxidizable surface to facet the oxidizable surface.

77. The plasma oxidation process of claim 73, wherein bombarding the oxidizable surface with energized ions comprises subjecting the oxidizable surface to a bias voltage.

78. The plasma oxidation process of claim 72, wherein regulating the oxidizing plasma activity comprises diluting the oxidizing plasma with an inert gas.

79. The plasma oxidation process of claim 72 further comprising providing a substrate having a back surface opposite a face surface, wherein the oxidizable surface comprises at least a portion of the face surface, and wherein regulating the oxidizing plasma activity comprises contacting the back surface with a cooling medium.

80. The plasma oxidation process of claim 72, wherein regulating the oxidizing plasma activity comprises applying an RF bias voltage to the oxidizable surface.

81. The plasma oxidation process of claim 72 further comprising:
providing a plasma chamber;
placing a substrate in the plasma chamber; and
igniting the oxidizing plasma after placing the substrate in the plasma chamber.

82. The plasma oxidation process of claim 72 further comprising igniting an inert gas plasma prior to igniting the oxidizing plasma.

83. The plasma oxidation process of claim 82 further comprising placing the oxidizable surface in the inert gas plasma.

84. The plasma oxidation process of claim 72 further comprising providing a plasma power source having an output power, and wherein regulating the oxidizing plasma comprises limiting the output power to a predetermined level.

85. The plasma oxidation process of claim 72, wherein the oxidizable surface comprises silicon.

86. The plasma oxidation process of claim 72, wherein the oxidizable surface comprises a semiconductor element of an antifuse device.

87. The plasma oxidation process of claim 72, wherein exposing an oxidizable surface to an oxidizing plasma comprises exposing the oxidizable surface to a plasma comprising oxygen.

88. The plasma oxidation process of claim 72, wherein regulating the oxidizing plasma activity comprises applying a bias voltage and sputtering a portion of the oxide film while simultaneously forming the oxide film.

89. A process for fabricating an oxide film in a semiconductor device comprising the steps of:

forming a semiconductor layer;

exposing the semiconductor layer to a plasma comprising oxygen,

wherein the plasma has an activity relative to the semiconductor layer;

forming an oxide film on the semiconductor layer; and

regulating the plasma activity to limit a rate of formation of the oxide film by regulating at least one of the following: reaction kinetics, growth initiation, and surface energy.

90. The process of claim 89, wherein the step of forming a semiconductor layer comprises forming a doped semiconductor layer.

91. The process of claim 89, wherein the step of forming a semiconductor layer comprises forming a silicon layer.

92. The process of claim 89, wherein the step of forming a semiconductor layer comprises forming a germanium layer.

93. The process of claim 89 further comprising forming an electrically conductive layer prior to forming the semiconductor layer.

94. The process of claim 89, wherein the oxide film comprises a gate oxide layer.

95. The process of claim 89, wherein the oxide film comprises a passivation layer.

96. A process for fabricating a dielectric film in a semiconductor device comprising the steps of:

exposing an oxidizable surface to a plasma comprising an oxygen species and a nitrogen species,

wherein the plasma has an activity relative to the oxidizable surface;

forming an oxynitride film on the oxidizable surface; and

regulating the plasma activity to limit a rate of formation of the oxynitride film by regulating at least one of the following: reaction kinetics, growth initiation, and surface energy.

97. The process of claim 96, wherein the nitrogen species comprises a compound selected from the group consisting of nitrogen, ammonia and nitrous oxide.

98. The process of claim 96, wherein the step of forming an oxynitride film comprises a gate oxide layer.

99. The process of claim 96, wherein the step of forming an oxynitride film comprises a passivation layer.

100. The process of claim 96, wherein the step of forming an oxynitride film comprises an antifuse layer.

101. The process of claim 96, further comprising subjecting the oxidizable surface to a plasma containing a nitrogen species prior to exposing the oxidizable surface to a plasma comprising an oxygen species and a nitrogen species.

102. The process of claim 101, wherein subjecting the oxidizable surface to a plasma containing a nitrogen species comprises subjecting the oxidizable surface to a plasma formed by a gas selected from the group consisting of nitrogen, nitrous oxide and ammonia.

103. A process for fabricating an oxide film in a semiconductor device comprising the steps of:

exposing an oxidizable surface to a plasma comprising oxygen,

wherein the plasma has an activity relative to the oxidizable surface;

forming an oxide film on the oxidizable surface;

regulating the plasma activity to limit a rate of formation of the oxide film by regulating at least one of the following: reaction kinetics, growth initiation, and surface energy; and

forming a silicon nitride layer overlying the oxide film.

104. The process of claim 103, wherein the step of forming a silicon nitride layer comprises plasma deposition of silicon nitride.

105. The process of claim 103, wherein the step of forming a silicon nitride layer comprises chemical vapor deposition of silicon nitride.

106. The process of claim 103, further comprising subjecting the oxidizable surface to a plasma containing a nitrogen species prior to exposing the oxidizable surface to a plasma comprising oxygen.

107. The process of claim 106, wherein subjecting the oxidizable surface to a plasma containing a nitrogen species comprises subjecting the oxidizable surface to a plasma formed by a gas selected from the group consisting of nitrogen, nitrous oxide and ammonia.

108. A process for fabricating a dielectric film in a semiconductor device comprising the steps of:

exposing an oxidizable surface to a plasma comprising an oxygen species,

wherein the plasma has an activity relative to the oxidizable surface;

forming an oxide film having an upper surface on the oxidizable surface;

regulating the plasma activity to limit a rate of formation of the oxide film by regulating at least one of the following: reaction kinetics, growth initiation, and surface energy; and

forming an oxynitride region at the upper surface of the oxide film.

109. The process of claim 108, wherein the step of forming an oxynitride region comprises subjecting the oxide film to a plasma containing a nitrogen species.

110. The process of claim 109, wherein subjecting the oxide film to a plasma containing a nitrogen species comprises subjecting the oxide film to a plasma formed by a gas selected from the group consisting of nitrogen, nitrous oxide and ammonia.

111. The process of claim 108, further comprising subjecting the oxidizable surface to a plasma containing a nitrogen species prior to exposing the oxidizable surface to a plasma comprising oxygen.

112. The process of claim 111, wherein subjecting the oxidizable surface to a plasma containing a nitrogen species comprises subjecting the oxidizable surface to a plasma formed by a gas selected from the group consisting of nitrogen, nitrous oxide and ammonia.

113. A plasma oxidation process comprising:

exposing an oxidizable surface to an oxidizing plasma,

wherein the oxidizing plasma has an activity relative to the oxidizable surface;

forming an oxide film on the oxidizable surface; and

regulating the oxidizing plasma activity to limit a rate of formation of the oxide film to a predetermined growth rate while the oxidizable surface is being exposed to the oxidizing plasma.

114. The plasma oxidation process of claim 113, wherein regulating the oxidizing plasma activity comprises bombarding the oxidizable surface with energized ions prior to exposing the oxidizable surface to the oxidizing plasma.

115. The plasma oxidation process of claim 114, wherein bombarding the oxidizable surface comprises bombarding the oxidizable surface to remove contaminants from the oxidizable surface.

116. The plasma oxidation process of claim 114, wherein bombarding the oxidizable surface comprises bombarding the oxidizable surface to remove other oxide layers present on the oxidizable surface.

117. The plasma oxidation process of claim 114, wherein bombarding the oxidizable surface comprises bombarding the oxidizable surface to facet the oxidizable surface.

118. The plasma oxidation process of claim 114, wherein bombarding the oxidizable surface with energized ions comprises subjecting the oxidizable surface to a bias voltage.

119. The plasma oxidation process of claim 113, wherein regulating the oxidizing plasma activity comprises diluting the oxidizing plasma with an inert gas.

120. The plasma oxidation process of claim 113 further comprising providing a substrate having a back surface opposite a face surface, wherein the oxidizable surface comprises at least a portion of the face surface, and wherein regulating the oxidizing plasma activity comprises contacting the back surface with a cooling medium.

121. The plasma oxidation process of claim 113, wherein regulating the oxidizing plasma activity comprises applying an RF bias voltage to the oxidizable surface.

122. The plasma oxidation process of claim 113 further comprising:
providing a plasma chamber;
placing a substrate in the plasma chamber; and
igniting the oxidizing plasma after placing the substrate in the plasma chamber.

123. The plasma oxidation process of claim 113 further comprising igniting an inert gas plasma prior to igniting the oxidizing plasma.

124. The plasma oxidation process of claim 123 further comprising placing the oxidizable surface in the inert gas plasma.

125. The plasma oxidation process of claim 113 further comprising providing a plasma power source having an output power, and wherein regulating the oxidizing plasma comprises limiting the output power to a predetermined level.

126. The plasma oxidation process of claim 113, wherein the oxidizable surface comprises silicon.

127. The plasma oxidation process of claim 113, wherein the oxidizable surface comprises a semiconductor element of an antifuse device.

128. The plasma oxidation process of claim 113, wherein exposing an oxidizable surface to an oxidizing plasma comprises exposing the oxidizable surface to a plasma comprising oxygen.

129. The plasma oxidation process of claim 113, wherein regulating the oxidizing plasma activity comprises applying a bias voltage and sputtering a portion of the oxide film while simultaneously forming the oxide film.

130. A process for fabricating an oxide film in a semiconductor device comprising the steps of:

forming a semiconductor layer;

exposing the semiconductor layer to a plasma comprising oxygen,

wherein the plasma has an activity relative to the semiconductor layer;

forming an oxide film on the semiconductor layer; and

regulating the plasma activity to limit a rate of formation of the oxide film to a predetermined growth rate while the semiconductor layer is being exposed to the plasma.

131. The process of claim 130, wherein the step of forming a semiconductor layer comprises forming a doped semiconductor layer.

132. The process of claim 130, wherein the step of forming a semiconductor layer comprises forming a silicon layer.

133. The process of claim 130, wherein the step of forming a semiconductor layer comprises forming a germanium layer.

134. The process of claim 130 further comprising forming an electrically conductive layer prior to forming the semiconductor layer.

135. The process of claim 130, wherein the oxide film comprises a gate oxide layer.

136. The process of claim 130, wherein the oxide film comprises a passivation layer.

137. A process for fabricating a dielectric film in a semiconductor device comprising the steps of:

exposing an oxidizable surface to a plasma comprising an oxygen species and a nitrogen species,

wherein the plasma has an activity relative to the oxidizable surface;

forming an oxynitride film on the oxidizable surface; and

regulating the plasma activity to limit a rate of formation of the oxynitride film to a predetermined growth rate while the oxidizable surface is being exposed to the plasma.

138. The process of claim 137, wherein the nitrogen species comprises a compound selected from the group consisting of nitrogen, ammonia and nitrous oxide.

139. The process of claim 137, wherein the step of forming an oxynitride film comprises a gate oxide layer.

140. The process of claim 137, wherein the step of forming an oxynitride film comprises a passivation layer.

141. The process of claim 137, wherein the step of forming an oxynitride film comprises an antifuse layer.

142. The process of claim 137, further comprising subjecting the oxidizable surface to a plasma containing a nitrogen species prior to exposing the oxidizable surface to a plasma comprising an oxygen species and a nitrogen species.

143. The process of claim 142, wherein subjecting the oxidizable surface to a plasma containing a nitrogen species comprises subjecting the oxidizable surface to a plasma formed by a gas selected from the group consisting of nitrogen, nitrous oxide and ammonia.

144. A process for fabricating an oxide film in a semiconductor device comprising the steps of:

exposing an oxidizable surface to a plasma comprising oxygen,

wherein the plasma has an activity relative to the oxidizable surface;

forming an oxide film on the oxidizable surface;

regulating the plasma activity to limit a rate of formation of the oxide film to a predetermined growth rate while the oxidizable surface is being exposed to the plasma; and

forming a silicon nitride layer overlying the oxide film.

145. The process of claim 144, wherein the step of forming a silicon nitride layer comprises plasma deposition of silicon nitride.

146. The process of claim 144, wherein the step of forming a silicon nitride layer comprises chemical vapor deposition of silicon nitride.

147. The process of claim 144, further comprising subjecting the oxidizable surface to a plasma containing a nitrogen species prior to exposing the oxidizable surface to a plasma comprising oxygen.

148. The process of claim 147, wherein subjecting the oxidizable surface to a plasma containing a nitrogen species comprises subjecting the oxidizable surface to a plasma formed by a gas selected from the group consisting of nitrogen, nitrous oxide and ammonia.

149. A process for fabricating a dielectric film in a semiconductor device comprising the steps of:

exposing an oxidizable surface to a plasma comprising an oxygen species, wherein the plasma has an activity relative to the oxidizable surface;

forming an oxide film having an upper surface on the oxidizable surface;

regulating the plasma activity to limit a rate of formation of the oxide film to a predetermined growth rate while the oxidizable surface is being exposed to the plasma; and

forming an oxynitride region at the upper surface of the oxide film.

150. The process of claim 149, wherein the step of forming an oxynitride region comprises subjecting the oxide film to a plasma containing a nitrogen species.

151. The process of claim 150, wherein subjecting the oxide film to a plasma containing a nitrogen species comprises subjecting the oxide film to a plasma formed by a gas selected from the group consisting of nitrogen, nitrous oxide and ammonia.

152. The process of claim 149, further comprising subjecting the oxidizable surface to a plasma containing a nitrogen species prior to exposing the oxidizable surface to a plasma comprising oxygen.

153. The process of claim 152, wherein subjecting the oxidizable surface to a plasma containing a nitrogen species comprises subjecting the oxidizable surface to a plasma formed by a gas selected from the group consisting of nitrogen, nitrous oxide and ammonia.

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First Named Inventor	Michael A Vyvoda
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Examiner Name	Fernando L. Toledo
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ENCLOSURES *(Check all that apply)*

- ☐ Fee Transmittal Form
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  - ☐ After Final
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- ☐ Extension of Time Request
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- ☐ Information Disclosure Statement
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- ☑ Appeal Communication to TC **(Appeal Notice, Brief, Reply Brief)**
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Firm Name	SanDisk Corporation		
Signature			
Printed name	Pamela J. Squyres		
Date	April 13, 2006	Reg. No.	52246

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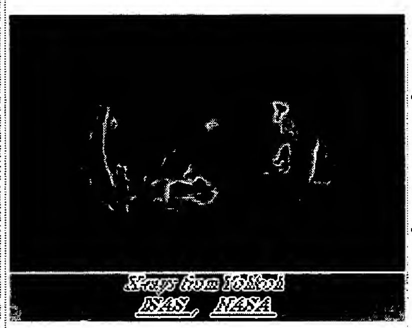
Exhibit A

What is a Plasma?

Plasma is overwhemingly the dominant constituent of the universe as a whole. Yet most people are ignorant of plasmas. In daily life on the surface of planet Earth, perhaps the plasma to which people are most commonly exposed is the one that produces the cool efficient glow from fluorescent lights. Neither solid, nor liquid, nor gas, a plasma most closely resembles the latter, but unlike gases whose components are electrically neutral, plasma is composed of the building blocks of all matter: electrically charged particles at high energy.

Plasma is so energetic or "hot" that in space it consists soley of ions and electrons. It is only when plasma is cooled that the atoms or molecules that are so predominant in forming gases, liquids, and solids that we are so accustomed to on Earth, is possible. So, in space, plasma remains electrically charged. Thus plasmas carry electric currents and are more influenced by electromagnetic forces than by gravitational forces. Outside the Earth's atmosphere, the dominant form of matter is plasma, and "empty" space has been found to be quite "alive" with a constant flow of plasma.



Plasmas are conductive assemblies of charged particles, neutrals and fields that exhibit collective effects. Further, plasmas carry electrical currents and generate magnetic fields. Plasmas are the most common form of matter, comprising more than 99% of the visible universe.

Plasma is by far the most common form of matter known. Plasma in the stars and in the tenuous space between them make up over 99% of the visible universe and perhaps most of that which is not visible. On earth we live upon an island of "ordinary" matter. The different states of matter found on earth are solid, liquid, and gas. We have learned to work, play, and rest using these states of matter. Sir William Crookes, an English physicist, identified another, more fundamental, state of matter in 1879. In 1929, Nobel Laureate Irving Langmuir gave this state a name,*plasma*. He borrowed the term from medical science because the matter with which he worked resembled life itself. It formed cells through bifurcation and often acted in a complicated and unpredictable manner. Plasma is defined as an assemblage of charged particles called electrons and ions that react collectively to forces exerted by electric and magnetic fields.

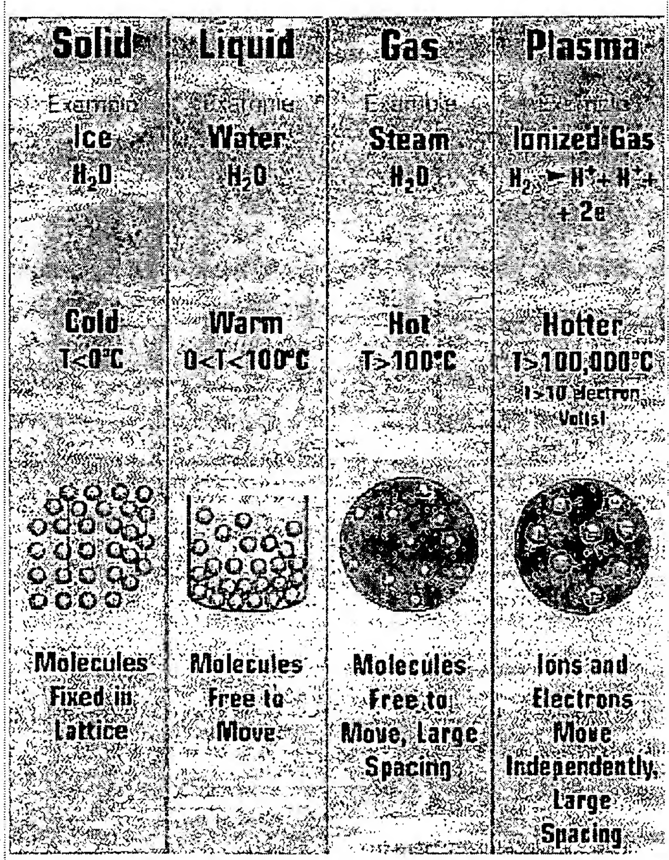
Given its nature, the plasma state is characterized by a complexity that vastly exceeds that exhibited in the solid, liquid, and gaseous states. Correspondingly, the study of the physical and especially the electrodynamical properties of plasma forms one of the most far ranging and difficult research areas in physics today. From spiral galaxies to controlled fusion, this little-known state of matter, the fundamental state, is proving to be of ever greater significance in explaining the dynamics of the universe and in harnessing the material world for the greatest technological result.

Solids	*Condensed matter*

	Compact (nuclear)
Liquids & Gases	*Fluid (Navier-Stokes)** Systems*
Plasmas	*Electromagnetic (Maxwell-Boltzmann)** Systems*

**There are only four dominant naturally-occurring states of matter although many other states of matter exist when considered broadly (see A. Barton, States of Matter, States of Mind, IOP Press, 1997).*

**The Navier-Stokes equations are basic equations for studies of fluids and neutral gas systems. The Maxwell equations for electromagnetism and the plasma Boltzmann equation are the basic equations for studies of electromagnetic systems of which plasmas are a prime example*



Plasma consists of a collection of free-moving electrons and ions - atoms that have lost electrons. Energy is needed to strip electrons from atoms to make plasma. The energy can be of various origins: thermal, electrical, or light (ultraviolet light or intense visible light from a laser). With insufficient sustaining power, plasmas recombine into neutral gas.

Plasma can be accelerated and steered by electric and magnetic fields which allows it to be controlled and applied. Plasma research is yielding a greater understanding of the universe. It also provides many practical uses: new manufacturing techniques, consumer products, and the prospect of abundant energy.

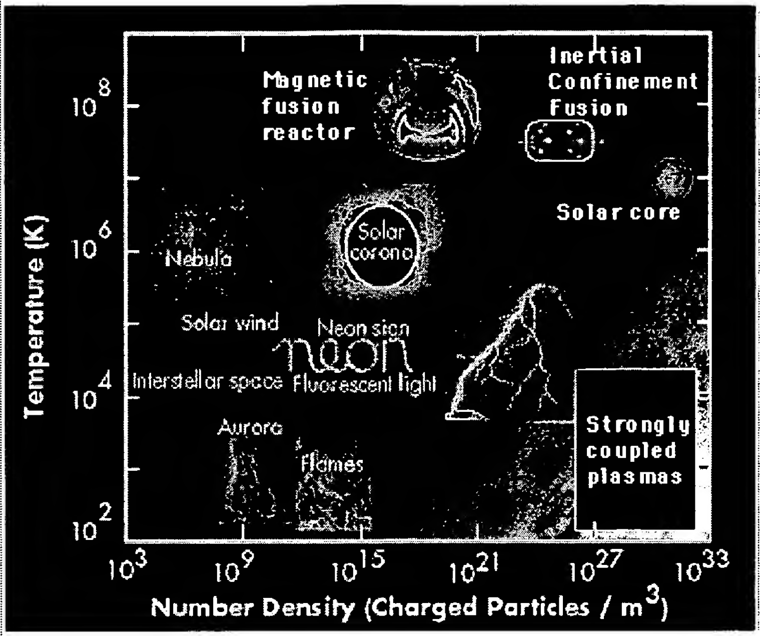
Courtesy of T. Eastman

In analysis, plasmas are far harder to model than solids, liquids, and gases because they act in a self-consistent manner. The separation of electrons and ions produce electric fields and the motion of electrons and ions produce both electric and magnetic fields. The electric fields then tend to accelerate plasmas to very high energies while the magnetic fields tend to guide the electrons. Both of these mechanisms, the accelerated (or fast) electrons and the magnetic fields produce what is called *sychrotron radiation*, so called because it was first discovered in large magnetized containers of electrons beams in laboratories on earth.

Because of their self-consistent motions, plasma are rampant with instabilities, chaosity, and nonlinearities. These also produce electric and magnetic fields but also electromagnetic radiation. For example, all beams of electrons produce microwaves. Plasma science has, in turn, spawned new avenues of basic science. Most notably, plasma physicists were among the first to open up and develop the new and profound science of chaos and nonlinear dynamics. Plasma physicists have also contributed greatly to studies of turbulence, important for safe air travel and other applications. Basic plasma science continues to be a vibrant research area. Recent new discoveries have occurred in understanding extremely cold plasmas which condense to crystalline states, the study of high-intensity laser interactions, new highly-efficient lighting systems, and plasma-surface interactions important for computer manufacturing.

The term fundamental is used to denote plasma because the constituent components of plasmas, electrons and ions, are the longest lived particles know. Their lifetimes far exceed that of any other known particle. Thus long after other forms of matter and radiation have ceased to exist, it will have reverted back into the plasma state.

Where Are Plasmas?



The figure here illustrates where many plasma systems occur in terms of typical density and temperature conditions. Plasma temperatures and densities range from relatively cool and tenuous (like aurora) to very hot and dense (like the central core of a star). Ordinary solids, liquids, and gases are both electrically neutral and too cool or dense to be in a plasma state.

Plasmas are common in nature and found nearly everywhere. For instance, stars are predominantly plasma as are most space and astrophysical objects. However, plasmas are also found on Earth where they find a wide range of uses.

All of the following are examples where plasmas are to be found:

- Lightning!
- The Sun—from Core to Corona
- Fluorescent Lights and Neon Signs
- Nebulae - Luminous Clouds in Space
- The Solar Wind
- Primordial Fusion during the evolution of the Universe
- Magnetic Confinement Fusion Plasmas
- Inertially Confined Fusion Plasmas
- Flames as Plasmas
- Auroras - the Northern and Southern Lights
- Interstellar Space - it's not empty, it's a plasma!
- Quasars, Radiogalaxies, and Galaxies—they emit plasma radiation and microwaves
- Large Scale Structures of Galaxies—their filamentary and magnetized!
- Dense Solid State Matter—when shocked by nuclear explosion or earthquakes, emit both light and radio emission.

However, the full range of possible plasma density, energy(temperature) and spatial scales go far beyond this illustration. For example, some space plasmas have been measured to be less than 10-10 /m3 (13 orders of magnitude less than the scale shown in the figure!). On one extreme, quark-gluon plasmas (although mediated via the strong force field versus the electromagnetic field) are extremely dense

nuclear states of matter. For temperature (or energy), some plasma crystal states produced in the laboratory have temperatures close to absolute zero. On the other extreme, space plasmas have been measured with thermal temperatures above 10+9 degrees Kelvin and cosmic rays (a type of plasma with very large gyroradii) are observed at energies well above those produced in any man-made accelerator laboratory.

Understanding Plasmas

While all matter is subject to gravitational forces, the positively charged nuclei, or ions, and the negatively charged electrons react strongly to electromagnetic forces, as formulated by James Clerk Maxwell (1831-1879) and Hendrik Antoon Lorentz (1853-1928). because of this strong interaction with electromagnetism, plasmas display a compexity in structure that far exceeds that found in matter in the gaseous, liquid, or solid states. In addition to the cellular structure, most visible to us on the Sun, plasmas most often display a filamentary structure. This structure drives from the fact that plasma, becaue ot its free electrons, is an excellent conductor of electricity, far exceeding the conducting properties of metals such as copper or gold. For example, the ballast resistor in a fluorescent lighting system is included for good reason. The florescent gas, as weakly ionized as it is, would completely short circuit the electrical main supply without the resistor. Wherever charged particles flow in a neutralizing medium, such as free electrons in a background of ions, the charged particle flow or current produces a ring of magnetic field around the current, pinching the plasma into multi-filamentary strands of conduction currents.

Beyond the filamentation, by far the most distinguishing characteristic of energetic plasma in comparison with the states of matter on the crustal regions of planets is that plasma are prodigious producers of electromagnetic radiation.

Gases, liquids and solids can be ionized, by intense beams of laser light, intense electromagnetic pulses, and nuclear explosions. In each case, these states can be made to produce electromagnetic radiation but the phenomenon is weak and short lived and the degree of ionization weak compared to plasma. Errors in perception have also been made, especially in the case of 'Ionized Gases,' a topic studied intensely in the early 1900's. However, gases and plasmas are distinct states of matter. The fluids states of gas and liquid are treated with the Navier-Stokes equation whereas plasmas are treated with the Boltzmann and Maxwell equations. The term 'plasma' is for everyone and not just for specialists. Sometimes the solar wind is described as a "vast stream of ions" but this leads to an incomplete description of the physics of the wind as electrons and electromagnetic fields are not included., In spite of their mathematical complexity, the acknowledgement of their existence throught space and utilization in industrial processes (80% of the manufacture of computing chips requires a plasma) it is time to acknowledge that

'plasmas' are for everyone.

Exhibit B

Exhibit D

SOHO Pick of the Week

Previous Picks of the Week

Green Arches (December 10, 2004)

Hi-res TIF (1.4M)

Movies:
MPEG: large (1.6M), small (576k)
QT (7.8M)

As an active region approached the edge of the Sun, its many towering arches became visible (at least for SOHO) for several days (Dec. 4 - 6, 2004). The subtle structures are fine and web-like as they gracefully shift and sway above the bright active region. It is hard to believe that these loops rise above the Sun to a height many times the size of Earth.

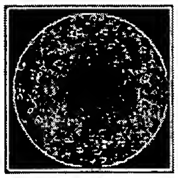
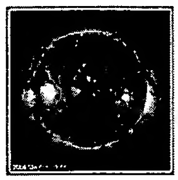
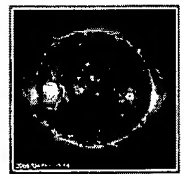
What are they? The gas in the Sun's outer atmosphere is so hot that collisions among the atoms strip off most of the electrons -- creating a gas of positively charged ions and negatively charged electrons, known as a plasma. Electromagnetic forces make it difficult for charged particles to cross magnetic field lines; instead, the plasma is trapped in tubes of magnetic flux, and the bright regions show us where there's both lots of plasma and a strong magnetic field. The green color is just a tone added to the black and white images to make it easier to tell what specific wavelength of light an imager is observing.

Previous Picks of the Week

SOHO began its Weekly Pick some time after sending a weekly image or video clip to the American Museum of Natural History (Rose Center) in New York City. There, the SOHO Weekly Pick is displayed with some annotations on a large plasma display.

If your institution would also like to receive the same Weekly Pick from us for display (usually in Photoshop or QuickTime format), please send your inquiry to steele.hill@gsfc.nasa.gov.

Also visit:

Hotshots	Best of SOHO	Latest Images	SOHO Gallery
			

Last modification: December 22, 2004
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Questions about our mission, the spacecraft and science, please check: Dr. SOHO.

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